

Cork Institute of Technology

Bachelor of Science in Applied BioSciences – Stage 1

(NFQ Level 7)

Summer 2007

Physics

(Time: 3 Hours)

Answer **FIVE** questions only.

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SHOW ALL WORKING.

$$h = 6.6 \times 10^{-34} \text{ J s};$$

$$c = 3 \times 10^8 \text{ ms}^{-1};$$

$$g = 9.81 \text{ ms}^{-2};$$

$$e = 1.6 \times 10^{-19} \text{ C};$$

$$N_A = 6 \times 10^{23} \text{ mol}^{-1};$$

$$1 \text{ a.m.u.} = 1.66 \times 10^{-27} \text{ kg}.$$

Q1 (a) An ice skater of mass 80 kg travelling at 3.0 ms^{-1} due West is thrown a ball of mass 1.5 kg travelling at 25 ms^{-1} due East. The skater catches the ball and the skater and ball then move together with a common velocity v .

(i) State the *equation* for the *Law of Conservation of Momentum* for two colliding objects.

(ii) Determine the *value* and *direction* of v . (7 marks)

(b) A car of mass 1400 kg travelling with an initial velocity of 50 ms^{-1} brakes with a deceleration of 2.0 ms^{-2} for 12.0 s.

(i) What *displacement* (s) does the car travel in this time? (5 marks)

(ii) State *Newton's 2nd Law*. Hence determine the *braking force* (F) of the car.

(4 marks)

(iii) Calculate the *kinetic energy* (K) of the car for its initial velocity (4 marks)

- Q2 (a) (i) State *Ohm's Law* (2 marks)
- (ii) What is an *electric current*? (2 marks)
- (b) The emf (\mathcal{E}) of a battery is 6.0 V. When the battery is connected to a $20\ \Omega$ resistor, a potential difference of $V_R = 4.0\ \text{V}$ is measured across the resistor. Calculate:
- (i) The *circuit current* (I) and the *internal resistance* (r) of the battery.
- (ii) The *power* (P) dissipated in the resistor. (10 marks)
- (c) Calculate the *equivalent resistance* (R_e) when resistors $R_1 = 10\ \Omega$, $R_2 = 40\ \Omega$ and $R_3 = 80\ \Omega$ are connected:
- (i) in *series*;
- (ii) in *parallel*. (6 marks)

- Q3 A student performs an experiment on radioactive $^{13}_7\text{N}$ gas, which is an isotope of nitrogen. The initial number of radioactive atoms is $N_0 = 6.9 \times 10^{16}$ and the decay constant $\lambda = 1.16 \times 10^{-3}\ \text{s}^{-1}$.
- (a) What do the terms *isotope* and *atomic number* mean? (4 marks)
- (b) Determine the *initial activity* (dN/dt) of the radioactive decay of $^{13}_7\text{N}$. (5 marks)
- (c) Calculate the *half life* (τ) for the radioactive decay of $^{13}_7\text{N}$. (6 marks)
- (d) If the decay of $^{13}_7\text{N}$ is by the emission of a beta particle to form a carbon nucleus, write the *radioactive decay equation* for this decay. (3 marks)
- (e) Name TWO other types of radiation emitted in radioactive decay processes. (2 marks)

Q4 (a) Define:

- (i) *specific heat capacity* (2 marks)
- (ii) *latent heat of vapourisation* (2 marks)
- (iii) *latent heat of fusion* (2 marks)

(b) A block of ice is heated from -20°C to $+110^{\circ}\text{C}$ by a heater supplying heat at a steady rate.

Sketch a graph of temperature θ [y-axis] versus time t [x-axis] and explain what is happening for the following three regions of the graph:

$\theta = 0^{\circ}\text{C}$; $0 < \theta < 100^{\circ}\text{C}$; $\theta = 100^{\circ}\text{C}$. (6 marks)

(c) When 2.1 kJ of heat is removed from 100 g of a substance, its temperature is observed to decrease from 40°C to 10°C . What is the *specific heat capacity* of the substance?

(8 marks)

Q5 (a) A sodium lamp has a wavelength of 590 nm. Calculate:

- (i) the *frequency* of the sodium light. (4 marks)
- (ii) the *energy* of the sodium light emitted. (3 marks)
- (iii) the *period* of the wave. (3 marks)

(b) Distinguish between *longitudinal* and *transverse waves* and give an example of each.

(4 marks)

(c) Sketch diagrams to show how light waves from two coherent sources with the same amplitude can combine to give: (i) *constructive interference*, (ii) *destructive interference*.

Label the *amplitude* and *wavelength* of the waves on one of the diagrams. (6 marks)

Q6

(a) A diffraction grating has 5000 lines per centimetre and produces a *third order* line for certain monochromatic light at 60.32° . Determine:

- (i) the *grating spacing*, d . (3 marks)
- (ii) the *wavelength* of the monochromatic light. (5 marks)
- (iii) the *angle* of the first order image. (2 marks)

(b) A diverging lens of focal length 25 cm is used to view a coin, which is 50 cm from the lens.

- (i) *Where* is the image of the coin formed? Is the image formed *real* or *virtual*? (4 marks)
- (ii) What is the *magnification* of the image? (2 marks)
- (iii) Draw a *ray diagram* of the arrangement. (4 marks)

Q7 (a) A diving pool has a width of 2.0 m, a length of 5.0 m and a depth of 15.0 m. It contains water with a density of 1000 kg m^{-3} .

- (i) What *weight* of water is contained in the diving pool? (6 marks)
- (ii) What *pressure* is exerted on a diver at the bottom of the diving pool? (4 marks)

(b) The needle of a syringe has vaccine flowing through it at a velocity of 1.4 ms^{-1} . The vaccine then flows into a vein of cross-sectional area $1.5 \times 10^{-6} \text{ m}^2$. The needle of the syringe has a bore of radius 0.50 mm. Determine:

- (i) The *area of the bore* of the needle; (3 marks)
- (ii) The *volume flow rate* through the needle of the syringe; (3 marks)
- (iii) The *velocity of flow* through the vein. (4 marks)